Emergency Preparedness Canada

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THE VALUE OF LIFE-
THE STATE OF THE ART AS OF 1985

A report prepared for Emergency Preparedness Canada
by

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The contents of this report do not necessarily represent the official views of the Government of Canada or of Emergency Preparedness Canada.

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THE VALUE OF LIFE: THE STATE OF THE ART AS OF 1985

I. INTRODUCTION

For some period of time, and particularly since World War II, there has been an increasingly strong tendency to take a quantified approach to the study of societal problems, non-material as well as material. One consequence has been the wide spread application of cost-benefit (C/B) techniques to Emergency Measures (EM) management. The C/B approach ideally brings all of the factors relevant to a topic into one quantification scheme, generally involving the use of a common scale or metric. It was inevitable, therefore, that, as lives saved is frequently one of the very major benefits yielded by EM, the topic of the assessment of the worth of those lives would arise.

This topic, often referred to as the Value of (Human) Life (VOL), has indeed become a lively one, not only for EM but for safety considerations in general. The degree of activity is reflected by the large body of literature which has developed. The literature, however, is not only large but reflects a variety of approaches which have resulted in correspondingly wide range of numerical estimates of the VOL.

Emergency Preparedness Canada (EPC) has felt it appropriate, therefore, to commission this study of the topic, both as an element in its C/B methodology, and in EM management in general, with the specific aim of reporting on:

a) The rationales and approaches which have been used in establishing the various estimates of the VOL;

b) The resulting range of values;

c) The contrasts and inconsistencies between the approaches; and

d) The approaches suggested for use in varying circumstances.

II. STRUCTURE OF THE REPORT

Following this Introduction, the paper discusses:

a) The methodology employed, including the constraints and limits; the Methodology section also briefly discusses the Bibliography.

b) To introduce the substance of the topic, the next section describes the Setting of the Study - that is, the relation of VOL to EM and, in particular how this affects the approaches and how it relates to certain philosophical issues.

c) The next section then describes and gives critiques of:

(1) The various approaches to the VOL topic;
(2) Their origin; and
(3) The numerical results.

This section ends with a summary tabulation of the estimated of the VOL, and their bases.

d) A Discussion section is then offered which aims to review the various aspects of the topic keeping in mind the perspective of an EM decision-maker or analyst.

e) The paper concludes with a Summary section which responds directed to the aims of the Study.

III. METHODOLOGY

This study took the form of a critical literature review. The original sources were studied, as well as the reviews which have taken place (all references in the study are from the bibliography). This information was then brought together to provide a picture of each approach.

Due to the nature of the developments in this field (which will be described) the direct examination of sources was confined to the post-'74 period. The Bibliography, however, for certain individual references, extends beyond 1974.

The Bibliography has been drawn up so an analyst who wished to review the field in, say 1990, would only have to examine the post-'85 period' and would, in addition, have a basis to enable individual aspects to be traced back through the references and examined in greater detail than is provided here.

It should be noted that in terms of both the literature itself and the sources of the numerical value estimates, sources are very largely of U.S. origin with some contributions from the U.K., and a few from continental Europe.

IV. SETTING OF THE STUDY

1. VOL IN GOVERNMENT DECISION-MAKING

A point repeatedly made in connection with the topic of VOL is that this valuation cannot be avoided; it is made - whether appropriately or inappropriately; whether for better or worse - when decisions are made regarding, for example, the investment to be made to achieve a certain safety standard on a highway, in some way a VOL figure is associated with that decision. It can be, and has been, argued that many of these decisions could conceivably be put quite directly to the individual at risk so that no abstract valuation need be made. Nevertheless, the fact is that currently and for the foreseeable future, governments will be making some of these valuations, either implicitly in certain decisions, or explicitly in C/B analyses.

And this is particularly the case with EM management which is predominantly a government activity, and where life-saving is very frequently a component of the package of benefits and may, in fact, be the predominant benefit. It seems fair to say that government decisions will predominate in EM.

The foregoing remarks regarding the role of government apply with particular force in Canada. The Canadian ethos places a particular responsibility on government to plan for, and manage EM.

2. THE MEANING OF VALUE OF LIFE (VOL)

Cost-benefit analysis of EM within Canadian governments will therefore, frequently involve the VOL. And here our nomenclature and terms do us a disservice. For, in effect, we are <u>not</u> treating the worth of a human life in a theological sense; or, to put it in other terms, we are <u>not</u> talking about the value of a soul - which could literally be described as priceless.

Further, effectively, we are not talking about the value of a (human) life. Rather, as can be inferred from the setting of the use of the numerical estimate, we are talking about the numerical value of a parameter to be used in decision analysis or C/B studies.

And in these studies, the parameter is used to represent the monetary value in calculating the worth of a reduction in risks; thus, we are not talking about the value of a life but the value of life saving.

Early studies (up to the late '70s) in their treatment of this topic, do take the approach - which is reflected also in the language, of actually valuing the worth of a life. Concepts have evolved, however, and these paragraphs are "signalling" where the intellectual trail will come out.

Moreover, this parameter, as it has been developed, represents the worth of a marginal reduction in risk; it could be conceived of as the slope of the "Worth of the Risk Reduction" curve when the risks of death are small-say roughly of the value of 10^{-4} per year.

As can be surmised from these remarks, the evidence is that the value of this parameter should be estimated by a range, rather than a single number. The factors, leading to the variation in the estimate, and which extend beyond the aspect of different risk levels, will be discussed subsequently.

As an additional point of clarification, we are discussing of the reduction in the risk to a population - a reduction in the probability applied to a statistical group. This point receives some emphasis in the literature as:

a) Western society will go to very great lengths to save the (threatened) life of a known/named individual. Search and Rescue operations are a case in point. (It is of interest to note, though, that even in these cases a search would be terminated at some point - which implies some VOL; a topic which does not seem to have been explored in Canada. See recommendation on page 43).

b) If only one individual is threatened then, even if that person is abstract/unknown, depending on the circumstances the rationale of government action and the justification for an investment by society as a whole can be questionable.

As an additional distinction, the risk that is at issue is that of premature death -not a lingering, illness-induced death* - and, specifically does not include injury or general life shortening effects. (Again, another source of variation in the estimates is that some have effectively lumped death and injury together).

Our focus is on the value of the parameter which should be used in quantitative analyses. For practical purposes these analyses can be thought of as C/B studies. Reference will be made, however, in the Discussion Section to the cost-effectiveness approach as well - i.e. where options yielding equal effectiveness are compared to identify, generally, the minimum cost approach. (In this field the cost-effectiveness approach compares the "cost per life saved" to determine which option costs the least).

In the study, we will discuss the moral/ethical aspects only to the extent required to establish or clarify the rationale. The nature of the use of the parameter within a C/B analysis will not be discussed either, as being beyond the scope of our task, except where it is relevant to the topic at hand - for example, in considering a critique of an approach where that approach is criticized for not encompassing factors that other aspects of a C/B study could be expected to bring in. We will not, for example, attempt to respond in a general sense to the criticism that Cost (or Risk)/Benefit Analyses can obscure ethical problems such as distributive justice.

*It is of some importance, in reviewing the literature, to distinguish those studies which focus on medical treatment (e.g. Weinstein, et.al) from those concerned with accidental death;

3. VARIATION IN GOVERNMENT - ASSESSED VOL

Reference was made earlier to the appropriateness of this topic for EM consideration. There is a specific aspect of the application of the VOL** concept within government which lends weight to the worth of a review of the topic: the extremely wide variation in the implied value which exists over a range of government programs. Table I (overleaf) lists a number of these to illustrate the range and the gross nature of the distribution of these values. Graham and Vaupel give a similar listing which ranges from $0, for a highway safety case to $169.2 million, for the control of Acrylonite. A reasonable hope for the consideration of this topic in EM management would be the reduction - not necessarily the elimination - of this range.

**As noted, we are considering a life-saving/risk reduction, parameter value not the value of a life; nevertheless, for convenience's sake we will continue to use VOL as an abbreviation.

TABLE I

Value of Human Life Imputed in Government Studies (1)

1.	Nuclear Power Plant Hydrogen Recombiners, USA	$ 3 x 10^9
2.	Apartment Building Regulations, UK	1 x 10^8
3.	General Nuclear Safety, Public, UK	1 x 10^7
4.	Home Kidney Dialysis	6.4 x 10^5
5.	Clear Roadside Recovery Area, USA	2.8 x 10^5
6.	Mandatory Laps-shoulder Belts, USA	1.1 x 10^5
7.	Home Smoke Detectors, USA	8 x 10^4
8.	Road Regulatory Signs, USA	3 x 10^4
9.	Improved Road Maintenance, USA	2 x 10^4

(1) This table is an extract from Siddal, which lists 84 instances of imputed VOLs ranging from $ 3 x 10^9 to $ 2.5 x 10^1 and even negative values.

V. APPROACHES

1. OVERVIEW OF PHASES OF DEVELOPMENT

In the modern era, there have been three successive phases in the approaches to the topic of VOL:

- These started with an "Appropriate Level of Insurance" orientation in 1946;
- This was followed relatively quickly by an "Earnings Related" approach which considered the topic in terms of contribution to the GNP; and
- Since about 1975*, the quite pre-dominant approach is based on the concept of "Willingness to Pay" (WTP).

2. INSURANCE ORIENTATION

a. Concept

The work in 1946 by Dubin and Latka is often viewed as the starting point for modern work in VOL.

This approach was a natural outcome of the interest which they had, as employees of an insurance firm, in the question: "How much insurance should a man carry".

In this setting, the question almost dictates the answer - i.e. the question could be interpreted as asking what net income would a man's family unit lose with his (premature) death; and for which he should, therefore, provide as a minimum; and beyond this, what is the value of this loss at the point in time at which he insured himself. Putting this formulation in mathematical terms yields:

*This is a major factor in the decision to focus the Bibliography in the post-75 era.

Appropriate Insurance = Present Value of Future Earnings - Present Value of Consumption

or symbolically

PV(E) - PV(C)

b. **Current Status and Critique**

This approach shares many characteristics with current perspectives:

(a) It incorporates a probabilistic element reflecting the likelihood of death; i.e. future earnings are the Expected Future Earnings from year t_o:

$$\sum_{t=t_o}^{100} (Pst)(e_t) \frac{1}{(1+r)^{t-t_o}}$$

Where Pst = probability of being alive in year, t;

e_t = expected earnings in year, t;

t_o = base year for calculation;

r = discount rate;

and, similarly for consumption.

Certain characteristics of this formulation are of interest; it incorporates:

(a) The probability of death;

(b) The earnings of the individual as already noted, is reflected in the expression;

(c) Future monetary values are brought to the relevant point of time, t_o, through the use of a discount factor

$\frac{1}{(1+r)^{t-t_o}}$,

These factors continue to be relevant to the topic.

Despite these features, however, it can be seen that this approach does not respond directly to the question of the Value of (Human) Life, much less the value of a trade-off for the reduction in the risk of death.

3. EARNINGS RELATED (HUMAN CAPITAL) APPROACH

a. Concept

The orientation of the Insurance perspective meant, as noted, that it could not form the underpinning of the topic; rather in time the central question came to be seen as "What is the Value to Society from a given life". And, again, this almost dictated the analytical approach as the value to society was interpreted by the C/B community to be the future contribution of an individual to the economy.

The relation to a "Human Capital" approach can be seen in that this approach views a person as a "machine" contributing to the (national) "factory's" output. This contribution can be thought of as the value of the machine's output - and then arguing that a person's contribution to the national economy is what that economy is willing to pay in the form of earnings.

This meant, accordingly that it was just the first (earnings) term in the Insurance approach which was of concern.

It can be, as has been, argued that it should be the net contribution to the economy which properly represents the economic value of a person. (This would restore the insurance approach since the net contribution would be earnings minus consumption). However, the prevailing view was that what is of interest is the contribution to the national economy not what is done with the products of that economy - i.e. it does not involve the nature and level of consumption.

In mathematical terms, then, the VOL would be L_T,

where L_T, = Value of Life at age T of person

= Present Value of future earnings of i beyond age T

$$= \sum_{t=T}^{100} (E_{it})\,(1-r)^{-(t-T)}\,P_i\,(t|T))$$

with E_{it} = Earnings of i at age t

r = discount rate

$P_i(t|T)$ = Probability that i will be alive at age t, given that he is alive at age T.

The resulting values vary widely, of course, since they depend directly on a person' economic status. Typical reported values for workers are $51,500 ('67 US).

b. Current Status & Critique

The lifetime earnings approach was the prevalent, if not dominant approach, up to about 1975 (and even beyond that); during this period, while the views of the academic community had changed, the use of this technique was still widespread in government C/B analyses.

The argument which led to the fall from favour of this approach is as follows:

- This approach places no value on, for example, old people - whereas Western societies do value their lives (Critiques of the approach have pointed out that a small extension of the strictly economic approach would make the "elimination" of old people desirable as that action would increase net GNP).

- More generally, beyond the age category, the approach would yield different values according to sex and, as indicated, by economic class.

- Fundamentally, the ethos of Western society does not make the maximization of GNP the focus of life. Lifetime earnings to use a felicitous phrase of Schelling's measures the value of "livelihood", not of life.

By the mid-'70s, the underlying rationale of C/B analysis had been sufficiently well-established that the treatment of VOL flowed more or less naturally. This underlying rationale is to maximize the well being of the society, where the overall value to society of a course of action is the sum of the individual worths of the changes brought about by that course of action. Classical economic methodology precludes, however, the inter-personal comparison of worths of states of being. No accepted method has been found to compare the intensity with which one person enjoys a state of being as compared with the intensity felt by another individual. Consequently, when a calculation of societal well-being involves individuals, as such, the values to be summed should be the values assigned by these individuals. Making these individual values commensurable and consistent is, of course, the subject of much study and discussion.

Beyond these considerations there is a parallel argument, that it is elitist to effectively charge people for a service at a certain rate - i.e. to tax them and invest money in a service - without determining the value of the service to them. (This is not to deny that this is done, simply that it is not a fair approach when alternatives are open).

The earnings related approach consequently, lost its status as the "State of the Art" approach, a position which has now been accorded to the Willingness-to-Pay (WTP) approach.

4. WILLINGNESS TO PAY (WTP)

a. Concept

Cost-benefit analysis clearly requires that the values used accurately represent the true worths to individuals. And it seems fair to say that free market established* worths are taken as the best founded expressions of these values - one reason being that the (market) exchange value could be described as being the definition of "the" value.

In the case of VOL the problem has been to find the market: in this case, the primary market is the individual since no one else can buy that individual's life (leaving aside the quite marginal aspect of organ transplants which would require the loss of the donor's life).

The value question resolves itself, then, into the question of the worth to an individual of the reduction in the life-threatening risk - what he would be willing to pay, or trade, for that reduction. This is a question which can be addressed from the stand-point of economics, since economics concerns the assessment of such trade-offs.

Note that it is implicit in what has been said that it is the values of the individuals in the group at risk which are relevant to a given C/B study -although in many cases this group could be described as the "general public". But if the values of this group are not directly available, one of the responsibilities of the C/B analyst is to see that the values used are representative of the group at issue.

(In the case of children, it seems fair in this case to adopt the general approach of society by assigning to parents or guardians the role of valid surrogate decision-makers).

*Most of the controversy surrounding actual market results centres around whether the market is a free (and, thus, fair) market.

Following from this line of thought, the approach which replaced the life-time earnings perspective has been to turn from judging the worth to society as assessed by earnings to, rather, judging the value in the only market that exists -i.e. the one internal to the individual, and to do this by examining ways in which he, himself, expresses that value - in a phrase his willingness to pay (WTP) for the reduction in the risk to his life. Moreover, it is worth noting that this is a value which the individual himself is in the best position to judge.

Certain points should be underlined regarding this approach:

- The WTP studies do not concern an identified life, they do not concern the "struggle for life" of an identified individual but, rather, they are concerned with the risk of a "statistical death" to some member(s) of a sizeable population. The values imputed are derived from the study of the behaviour of this population.

- This foregoing point emphasizes the need for the population from which the values are derived to be representative of the population treated in the C/B study.

The problems with the WTP approach are implicit in its description: how do we identify and study the "market behaviour" which expresses WTP - this difficulty was undoubtedly a major factor in the continued use of the lifetime-earnings approach and forms of the insurance approach.

In addition, experience has shown - to, again anticipate a point - that WTP is, unsurprisingly, a function of economic status: the better-off generally being willing to pay a higher amount.

Nevertheless, the results of the study and application of the WTP approach have established it both theoretically and practically as the best founded approach in this topic.

b. Methods

As implied in the term, WTP, the various methods used to apply the approach all share the central characteristic of deriving the trade-offs which populations are willing to make to achieve a reduction in the risk of death at identified levels of risk.

(i) Labour Market Studies

The currently most prominent technique and, this study would judge to be, the most satisfactory, is to derive the premium which workers demand for assuming a higher risk in the more dangerous occupations.

The starting point in this was the work of Thaler and Rosen in 1976. They examined jobs requiring similar abilities and identified the difference in the wages as related to the accident rates. These wage differences were taken as the premiums which workers traded-off for the higher risks.

From these wage premiums and the associated risk levels, a figure for the VOL parameter was derived which was $200,000 ($US '67).

The Thaler-Rosen work rapidly established itself as a major contribution to the field. As such it also naturally attracted criticism: a major reservation (others will be discussed in connection with all labour markets studies) concerned the question of risk averseness. It has been well established (Cohen) that some individuals will "pay" (accept on economic penalty) to avoid risk - they will pay more for higher levels of certainty than the probabilities and pay-offs involved in a decision would justify. Others are positively attracted to risk. The argument concerning the Thaler-Rosen study was that the workers who received a "risk premium" almost by definition were much less risk averse then the general population; the derived values should not, therefore -

according to this argument - be applied for the general population. To get a more generally applicable figure a broader population should be used.

Smith (1976) carried out a study to overcome this perceived deficiency using the wage and risk differentials for whole industries rather than for the more focused occupations.

This study yielded a VOL figure of $2.3 million (U.S.'80). (Smith, 1979; Bailey; Viscusi, 1983).

A particular major reservation concerning this study was that the method yielded a value which included an imputed compensation for injury as well as for death -a characteristic which was true, also, of the Thaler-Rosen study. Smith has argued (1979) that injury is fully compensated for by Worker Compensation payments. However, other studies, (Bailey 1980) have yielded results which would invalidate this conclusion.

A study was done by Viscusi (1978) which was also industry based (vs occupation based)but which, however, allowed for injuries to isolate the death risk premium. His results were $1.5 million ($US '71). (Smith, 1979).

Despite the injury allowance, Viscusi's figures show the same characteristic of all industry-wide studies of yielding considerably higher figures than those which were job-focused.

Further considerations of these studies (e.g. Bailey, 1981) have indicated that that, when overall industries are studied:

(a) There is a mixing of the wage premiums for risk, with premiums for aspects such as higher qualifications; and

(b) a "spill-over" phenomenon appears to be at work; i.e. that the effect of the higher wages in the more dangerous (specific) occupations influences the other wages so that it appears that the less threatened workers have a higher VOL than is actually the case.

In support of (a) above, it should be noted that Dillingham used a cross section of a broad group of workers but in so doing allowed for skill differentials. His resulting estimate (as adjusted by Bailey - see below) was $376,000 (U.S. '78).

In 1981, Bailey undertook quite a thorough review of the work done to that time on VOL. In this work he adjusted the results for:

- Injury; for example, only 44% of the Thaler-Rosen value was attributed to death;
- A third party effect on insurance and survivor benefits; for example, these workers typically do not pay sufficient premiums to cover these risks; consequently others will have to pay;
- Income; as studies had demonstrated that WTP varied with income level;
- A third party effect through indirect business taxes; this is similar to the insurance point (above); here, employers' Workers Compensation contributions are insufficient;
- Inflation (to 1978);
- Costs borne by the immediate family.

The resulting figures ranged in from $170,000 to $600,000 (U.S. '78) Section 2 of Table II, page 30, shows the figures in more detail. The various figures allow for possible ranges in some of the parameters in the original studies and in the adjustment calculations.

This study judges that Bailey's review provides an excellent reference point for all subsequent work. (It is of interest that Viscusi (1983) cites Baily in a subsequent work but does not attempt to respond to Bailey's quite specific and detailed criticisms). Accordingly, the full set of the Bailey adjusted figures are given in Section II of Table II.

Bailey's review treated also techniques other than those labour market-based. These will be discussed subsequently, but it would be appropriate, here, to note that using all the data, his conclusion is that, when all factors are allowed for, the difference between figures derived from occupation-based groups and those derived from the general population indicate that variations in risk averseness are not as significant as was originally supposed.

(ii) Other Action-Based WTP Techniques

People exhibit an implied VOL in actions which they take, or behaviour which they exhibit, other than in the labour market.

Blomquist (1979) carried out a study of the use of seat belts which related the cost in time to buckle-up to the risk reduction, and allowed for socio-economic factors such as income.

His results were an estimate of $625,000 (US '85). However, when his figures were adjusted by Bailey (for indirect and third party costs), they ranged from $256,000-$715,000 (U.S. '78).

Poynter did a study on the effect of air pollution on house values which related the higher risk of death factor to those values. This study yielded a figure of $180,000 (U.S. '80).

It is noteworthy that a study by Brookshire also based on air quality valuation yielded values consistent with these.

In yet another area, Dardis examined the use of smoke detectors. In this case, the trade-off was determined from the willingness of people to pay for detectors at various levels of expenditures.

The VOL, here, was estimated at $145,000 $351,000 (US '80)).

This study has been criticized on the grounds that:

- It did not allow for the cost of installation; but these are quite small compared to the purchase price. (Most are probably self-installed).

- Protection was provided to the family unit rather than a single individual; consequently, more than one life might be saved in a given incident; but, the evidence is that single deaths very much predominate.

In the light of the counter-comments given above, the figures from this study are judged to provide a valid piece of evidence

(iii) Survey-Based WTP Techniques

A natural response to the problem of determining the VOL is to ask people directly what these are. Effectively, this was done by Acton 1973 using as a context the worth of life-saving in the case of heart attacks. His results have been described by himself as "close to" the Thaler-Rosen range of $170,000-$200,000 (U.S. '73). Other sources give his results as $500,000 (U.S. '78).

The Acton survey study is apparently the only one which applied this technique in a public survey of life and death situations. It is likely that this is due to the limitations which seem to be inherent in this method: the questions posed are hypothetical in nature and concern difficult topics - topics with which they are not familiar, the difficulty is compounded since those questioned must make rapid judgements regarding small changes in small probabilities (This is in contrast to action decisions which are real; generally do not have to be taken quickly, and to which the evidence acquired by the public over time can be brought to bear). Nevertheless, the magnitude is not inconsistent with the results of other studies.

In addition, the study is of interest in that it provides evidence that WTP increases with:

- Increasing probability of death;
- Increasing reduction in risk;
- Increasing concreteness and reality (which effectively argues for behaviour-oriented studies).

c. Annual Premium Considerations

In Bailey, values are worked out for the annual premium which a family would be willing to pay to halve the risk reduction implicit in moving to an average "safe" job. These values range from $300 to $1,300 (U.S.'78) when the occupation-based WTP values are used. In contrast, when the industry-based values are used, an annual premium of $10,000 is implified. Accordingly, it could be said that the occupation-based estimates meet a test of "reasonableness", while industry-based ones do not.

d. Overview of Estimates

There is, consequently, a triangulation fix on these values:

- the actual choices by occupational groups-which, internally, show a fairly consistent range of values;
- the actual choices by the whole population or large segements of the general public;
- the test of reasonableness.

These VOL estimates cover a fair range; this range, however, is not inordinate and is certainly very much narrower than the range of values implied in a number of government decisions.

e. Current Status

As noted, the WTP approach has become the canonical method for the estimation of VOL. The bulk of the discussions of the approach concern whether a particular technique gives a fair application of the concept rather than whether the concept is fair in itself.

f. Critique

As a fundamental critique it has been noted that "games" involving death do not allow for repeats - death is a one-shot affair. Accordingly the repetitive basis of an expected value approach is missing. This can be related to the problem of the meaning of probability in a single case event - i.e. where something can happen only once. And the response to both can be the same: the decision-maker can be said to ensvisage a (statistcal) range of (implicity equally likely) relevant future states of the world and judges the chance that the event will occur under each of these futures. In the case of action decisions, that decision-maker is informed by the evidence which he observes. As an example, he could be said to share vicariously the work life experiences of his fellows and

to be able to judge in this way the risk which he is running in a given occupation.

More specific critiques of the WTP approach (and in particular, of the labour market studies) can be related to the following topics:

a) Relevance (i.e. voluntary vs involuntary risk);

b) Fairness (is the job decision made freely and with full knowledge and insight into the working conditions);

c) Ethics (is it ethical to trade safety for dollars).

As previously noted, the voluntary/involuntary risk question reduces to a question of risk averseness: but the concern that the study population is not typical can be countered by observing that the workers who form the source population are not from the "tail" (extremes) of the (statistical) distribution of population traits - they represent, a wide range of "blue collar" workers, a major segment of the population which has not, to date at least, been identified with a great propensity to take risks.

As to the "fairness" of the wage-based estimates, there are essentially three aspects involved:

- Do the workers have the required information;
- Can they deal/assess this information;
- Can they apply the conclusions derived from this information.

It is the view of this study (which is supported by Hammerton et al, and Viscusi (1983)) that, topics with which people are reasonably familiar, they can make good estimates. Industrial accidents, driving conditions and household fires are topics with which the populations concerned are familiar. It could be said that a type of "folk wisdom" exists regarding the probabilities associated with these topics.

There is no doubt that in academic studies, people have demonstrated a tendancy to over-estimate small probabilities which would lead to an underestimation of the VOL. On the other hand, in some action situations they also underestimate small probabilities - lottery odds is a case in point. Moreove the academic study situations are unfamiliar ones.

For the second aspect - the assessment of the information, it could be argued that individuals display inconsistency in their compounding of probabilities in decision-making. In contrast, however, it is exactly an overall risk which the labour market assesses, not individual component risks - it is in this regard that a consensus develops. Rather than "safety" being an unobserved phenomenon, as has been argued, this study would argue that it is highly observed in the negative (accident-frequency) sense.

(Blomquist, in Jones-Lee (ed.) corrects certain VOL values based on an academic study of their assessment of certain risks. It must be questioned as to whether this type of adjustment is justified due to the lack of familiarity with the topic.

Reference has been made to a "fair market" valuation. The question can be raised as to whether a wage premium would be a fair representation if, in fact, the labour market did not permit mobility -if, in fact, a worker could not choose between jobs with different wage and risk characteristics. While no one would argue for a perfectly free and open labour market, it could be argued that the labour market

environment which pertained for these figures (1965-1980) did provide a high degree of mobility. It was not a time during which individuals were forced into jobs. It was a time in which industrial relations were such that appropriate wage differentials were not difficult to secure. (It has been suggested, that this aspect would benefit from a study of admittedly mobile trades which carry above average risk -flight engineers have been mentioned as a possible case in point.)

Regarding the ethical question as to whether it is ethical to trade jobs for safety, for the VOL topic the short response has to be that it is done all the time and, so far as can be foreseen, will continue to be done. In fact, one of the strong arguments for the WTP approach is that it would be unfair for government to force individuals to accept values different in EM applications from those which they choose for themselves - unfair either due to an undervaluation or to an overvaluation which imposes a too-high tax burden.

Beyond the three fairly fundamental critiques of WTP, the following points are also worth noting:

- The approaches mean that the value of life proper is joined by the worth of relief from anxiety; but this could very fairly be counted as a valid component of VOL - particularly in its applications in Emergency Planning C/B studies.

- The income level of some of the groups studied were below average, and the VOL would, accordingly, be somewhat below average. This factor may very well account for some of the range of values from the various studies.

Finally, regarding the validity of estimates based of wage premiums some studies (Smith (1979) yield evidence that wages, in general, do not compensate for certain disadvantageous features of jobs. These same studies, however, indicate that wages <u>do</u> adjust to compensate for risk of death.

As has been previously noted, the implicit value studies could be described as being in reasonably good accord with the labour-market results. (They, consequently, lend weight to the points that this blue collar work force is not abnormally risk averse, nor that it is not unduly impeded in mobility).

Regarding the WTP survey technique, despite the reservations which understandably arise as noted, recent work by Hammerton, Jones-Lee and Abbott gives rise to the cautious hope that in topics which are reasonably familiar to individuals, judgements are consistent.

It should be underlined that the WTP approach, either in general or for the bulk of the individual studies, does not assume linearity in the value - i.e. that the same parameter value does not apply for markedly different conditions; conditions concerning the individual's economic position or the risk situation.

Recent work indicates, however, that VOL estimates would apply not only marginally but to cover protracted periods of time. A study by Jones-Lee and Poncelct seems to indicate that the marginal and current period estimates - which, due to the nature of the studies, are the conditions under which estimates now apply - can be extended.

5. UTILITY FUNCTION APPROACH

a. Concept

In much of the work in the VOL topic, theoretical models have been developed to gain insights and some estimates of the VOL. Generally, these models used utility functions to express overall life satisfaction; these models can then be optimized in terms of a trade-off between the cost and the worth of risk reduction. These models, consequently, address the fundamental calculation which is seen to control an individual's decision regarding the investment which he would make to

reduce risk - namely, the sacrifice in quality of life now in exchange for a greater chance for life later.

In contrast to the studies which aimed at deriving VOL parameter values, for particular situations (e.g. risk, levels) the utility function approach - when the appropriate numerical results are included - allows a value to be calculated for a broad range of life situations. In addition, it can allow for a wider range of considerations, beyond the individual's perspective; e.g. the addition of a societal perspective.

Linnerooth (1979) discusses a generalized type of these models and illustrates their uses. And, in particular, she illustrates the concept that these models rest on the use of an expected value (in the mathematical sense) of lifetime utility covering the period which starts when the risk reduction decision is taken; this expected utility contrasts with models based on certain lifetime utilities.

b. **Consumption Models**

Usher's approach involves this very present versus future trade-off. The VOL which results from this calculation depends naturally on parameter values such as the time discount rate for future consumption. These values and, in fact, the form of the utility function could be described as reasonable.

It is of interest, therefore, that the results gave VOL estimates which for age 30 are markedly at variance with the WTP estimates (leaving aside those industry-based).

Two criticisms can be made regarding this approach:

- It is hypothetical rather than based on empirical evidence

- The same time discount factor is applied to move around in time both money and the satisfaction from a particular type of consumption. These two discount rates are not necessarily identical.

c. Other Utility Models

Other specific cases which exemplify this approach are:

- Keeney has developed a utility function which reflects societal as well as individual values; in particular, catastrophic situations are treated in a different fashion than simply adding up individual values.

- Among the more traditional models, Conley broadens the Usher approach by introducing the use of a vector of consumption and production activities (vs a single consumption enjoyment variable). The use of this concept requires, of course, that the exchange (monetary) value of various forms of consumption be estimated.

- Bodily uses a multi attribute decision approach which brings in the individual's concern for others.

A fair speculation is that utility models have become more prominent for two reasons:

- The spread in the use of utility models generally; and
- Their ability to cater for as wide a range of concerns as desired.

Their "weakness" is, essentially, the mirror image of this last point: the difficulty of establishing the required numerical values for these to represent these concerns. To date, these models could be said - with the notable exception of Usher - to have only yielded structural insights into the topic.

6. SUMMARY OF VOL ESTIMATES

Table II (overleaf), gives and annotates the values resulting from different estimates of the worth of the reduction in the risk of death. This table similarly, extracts for the sake of convenience those estimates which for the reasons already notedare judged to have the surest foundation. It records, also, the values used by various government agencies in their analyses.

It is of interest that the range from .28 x 10^6 to 1.92 x 10^6 ('85 C$) encompasses all of the WTP (occupation-based) and implied value estimates. Beyond this, there is a strong clustering in the .50 x 10^6 range.

TABLE II

1. Estimates of VOL Parameter

Study	Estimate (All in '85C$)(1)	Study Basis	References
N/A	$.20 \times 10^6$	Earnings	Bailey
Usher	$.28 \times 10^6$@age 30 $.16 \times 10^6$@age 60 $.08 \times 10^6$@age 80	Future Lifetime Utility (Cdn)	Usher
Portney	$.28 \times 10^6$	WTP: Housing decisions	Portney; Blomquist in Jones-Lee(ed)
Dardis	$.56 \times 10^6$	WTP: Smoke detectors	Dardis
Dillingham	$.64 \times 10^6$	WTP: Occupation based	Bailey, Smith
Thaler & Rosen	$.64 \times 10^6$-$.96 \times 10^6$	WTP: Occupation	Thaler & Rosen, Smith; (1979) Viscusi (1983)
Ghosh, Lees & Seal	$.66 \times 10^6$	WTP: Driving Characteristics (U.K.)	Ghosh, Lees & Seal
Blomquist	$.74 \times 10^6$	WTP: Seat-belt	Blomquist in Jones-Lee
Acton	$.79 \times 10^6$	WTP: Survey	Acton (1973); Zeckhauser & Leebaert
Brown	1.28×10^6-1.92×10^6	WTP: Occupation	Smith
Smith	3.2×10^6	WTP: Industry based	Bailey, Smith (1979) Viscusi (1983)
Viscusi	4.8×10^6	WTP: Industry	Smith (1979); Viscusi (1983)
Veljanorski	6.1×10^6-8.6×10^6	WTP: Industry (UK)	Smith (1979)

(1) Original figures were first inflation adjusted to 1985, and then converted to Canadian values (at $1 U.S. equals $1.38 Canadian). A reduction by multiplying by 0.9 was effected to allow for the best estimate of a different WTP at the lower Canadian GNP per capita - an effect which, of course, is non-linear.

TABLE II

2. Adjusted VOL Estimates ('85C$) (Ref: Bailey)

	Blomquist	Thaler & Rosen
Low	$.52 \times 10^6$	$.34 \times 10^6$
Intermediate	$.82 \times 10^6$	$.61 \times 10^6$
High	1.43×10^6	1.07×10^6

3. Government Agency VOL Values ('85C$) (Ref: Lave)

FAA (US)	$.43 \times 10^6$
NRC (US)	1.42×10^6
OSHA (US)	$2.84 \times 10^6 - 7.10 \times 10^6$
EPA (US)	$1.42 \times 10^6 - 10.65 \times 10^6$
DOT (UK)	$.3 \times 10^6$

VI. APPLICATION CONSIDERATIONS

Although the particulars of the use of the VOL parameter IN C/B analyses is not a central concern for this paper it must be given some consideration as there can be an interaction between the usage and rationale for applying the parameter at all, with the specific means for deriving its value.

A basic point should be reiterated in Canadian society, government frequently make decisions which affect life and death - or, less dramatically, and more accurately (as has been discussed), the risk of death. In this society, this is not an abnormal task and, in fact, is one which is expected of government.

Beyond this, it is of some importance to note, also, that in the overwhelmingly number of cases the risk-reducing measures are financed from general revenues for the benefit of a segement of the "general public".

1. FACTORS RELATED TO WTP

That the concept of an allowance for the VOL is applicable and justified does not, of course, eliminate all controversies concerning its application. In particular the dominant WTP approach may be inappropriate for certain reasons. These reasons and their counter-arguments are as follows:

- In his decision-making - in this case, in his assessment of the work of risk reduction - the individual ignores external social costs. Counter: It is one of the roles of a comprehensive C/B to take these into account in the overall balance.

- In certain circumstances, people may gamble on behalf of their heirs - e.g. in the case of air travel insurance. Counter: It would certainly be fair to eliminate or to discount, parameter values derived from the study of situations in which this could be a major distortation. Nevertheless, it is at least conceivable that this is an element in all WTP valuations made by a good-sized population. And as a widespread

phenomenon, concerns for heirs should be taken into account as a legitimate element.

2. CHANGE IN WTP WITH RISK LEVELS

There is good evidence that, not surprizingly, the WTP increases as the probability of death (risk level) increases. (Acton; Linneroth in Jones-Lee (ed.)) The evidence indicates, also, however, that the value of the increments to the VOL decrease as the risk of death increases, which indicates an upper limit to the VOL.

The existence and the level of this upper limit is not a critical topic, however, as the very large bulk of EM C/B analyses are not concerned with large risks.

3. RISK LEVELS

As the VOL will change depending on the risk level, it is important the figure used in a C/B analysis be derived for levels which are of the same order of magnitude as for the analysis situation. It should be noted, therefore, that for the studies discussed in this report, the annual risk of death was in the 10^{-3} to 10^{-5} range, with the bulk being at the 10^{-4} level.

It may be of incidental interest that there has been some discussion in the (Jones-Lee (ed) literature of 6.25×10^{-5} as an upper limit of acceptance risk.

4. PREVIOUS ECONOMIC COMPENSATION

There is an additional point related to usage, which is judged to have possibly particular relevance in the applictaion of the VOL concept in EM C/B studies: this is that' in at least some cases, VOL considerations may have already entered into economic decisions and been compensated for. An example, could be the reduced price of houses in a flood prone area. Successive

purchasers may will have benefited from these reductions; they should not receive benefits twice by the provision, at public expense, of a risk reduction measure. There is, however, one mitigating factor which justifies government intervention even in these situations: where the risks are misperceived or unknown. And this would seem to be true in a large number of cases.

5. USE OF A SINGLE PARAMETER VALUE*

Government works are normally financed from general revenue; thus, the general public is paying; but do the benefits flow to what could be called a segment of the general population. In certain cases it is likely that the population whose risk is being reduced is above or below average on an income scale. It could be argued that the higher income group would, from the empirical evidence, be willing to pay more than the "general public"; and, that, as they do pay more in taxes, they should receive a greater risk reduction. (And if it were practical and politically feasible to make a special charge this could be done). The converse argument would apply to the below average group. In these case, though, an over-riding idea is that of the redistribution of income through government. Progressive taxes are not applied to permit purchases of greater benefits, but as an equitable contribution to the commonweal. And in matters of life and death, public policy is conceived as being even-handed as between rich and poor - even though this idea may be violated in certain instances, albeit unintentionally.

An additional point which argues for the use of one range of estimates is that often it is not possible to specify, except in a very general sense, who will benefit from a risk reduction measure. Clearly, a measure related to occupational safety would very probably have a close focus. On the other hand, measures related to greographic areas (.e.g. flood or weather-effects control, or transportation modes) would very largely pertain to what could be termed the "general public".

*In this case, we are effectively referring to a single range of values.

A related aspect of usage provides a strong argument for the application of objective C/B studies to the risk situations. It is not difficult to identify, as in Table I, wide discrepancies in the implied VOL values in varying decisions. In particular, the contrast is sharp between directly "caring" programs such as in medicine, and the rather impersonal programs for highway safety. Other considerations enter to cause this difference - such as that, in general, the population benefiting from many medical programs has already undergone above average suffering. Nevertheless, although such differences quite probably cannot be eliminated - and possible, as indicated, should not be - C/B analysis can still play a useful service by making decision-makers conscious of the real effects of their choices.

In the light of these considerations, the use of a single, "general public" value for VOL would be jusitified except in the case of:

a) Peculiar and atypical demographics - and even here the re-distributional role of government is still relevant;

b) The population's income is above-average and the premium for extra protection can both be collected and applied.

c) Where different portions of the population threatened by the same phenomenon run risks at significantly different levels.

6. APPLICATION OF A RANGE OF VALUES IN C/B ANALYSIS

As has been indicated, the estimates of VOL cover a range of values. In such a situation, the conclusions of a C/B analysis would be best supported, if:

- A favourable C/B ratio can be obtained with the use of the low range of the estimate;

- An unfavourable ratio can be obtained even with the use of the highest range of the estimate.

7. SENSITIVITY OF RESULTS

Despite the understandable sensitivity in the theoretical discussions as to the validity of application of the values derived from a variety of studies, the evidence is that C/B studies using the VOL may be fairly insensitive to the range of values which comes from these studies. Graham and Vaupel report on the study of 57 analyses in which the C/B ratio was favourale to the course of action; in 34, the implied VOL was less than $170,000 (US '78) which meant that, as this figure is at the lower bound of estimates, the project was clearly worthwhile, 11 had implied VOLs of $170,000-$3,000,000 (US '78), an often accepted range of WTP estimates; in only the 12 where the implied VOLs were above $3,000,000 would the decisions have changed. Unfortunately, the study does not seem to have examined cases where the C/B ratio was unfavourable with a resulting rejection.

8. PRIVATE DECISION-MAKING

There is another approach to the overall question of VOL which could be adopted - to take it out of the C/B analysis realm altogether by publicizing the figure that has been used in the design of an equipment or facility; and, then, to let the public make a consumer-type decision as to whether the value, in association with the other characteristics, justifies the cost of purchase or use. This is certainly an intriguing approach which is quite consistent with the current de-regulatory climate. (It is also related to the argument that government should not become involved if there have been compensating economic benefits realized for the assumption of greater risk). The problem with the application of the idea to the public sphere could be expressed as follows: although, the concept could be applied most readily in the private market where a range of choices could be available, public goods are generally "one of a kind" so that only generally alternative choices would not be available.

9. APPLICATION CRITERIA

In a C/B application the following considerations should apply:

- The risk levels should be similar between source study and analysis;
- The populations should also be similar;
- Except in the unusual circumstances described, a single value (or range of values) applicable to the general public should be used;
- Economic compensation for the risks incurred should be taken into account.

VII. DISCUSSION

To this point, the paper has recorded the adjudged positive balance in the cases for:

- The validity of the use in C/B analyses of a well-defined VOL parameter;
- The use of the WTP concept and of a particular range of estimate values which come from the application of this concept; and
- The application of certain criteria for the use of the parameter.

This discussion section considers other perspectives on the parameter and nuances in the argument.

1. GENERAL POINTS REGARDING THE VOL PARAMETER

It could be argued that, WTP aside, there are certain lives which are of such worth to society that extraordinary expenditures to reduce risks to them would be justified. One conference could identify only 5-10 individuals in the U.S. population which were judged to be of such outstanding worth that they fell in this category. Even if the estimate were in error by orders of magnitude, it could be concluded that this would not be a significant consideration in general C/B studies.

And at this point it is worth recalling that the VOL concept is relevant only to a fair-sized population, <u>not</u> to a particular life.

This last point is a major reason why legal settlements are <u>not</u> a good guide to the estimation of the parameter value: court settlements concern a particular life, the particular details of a death and the circumstances of the survivors. It is also not clear, to put it bluntly, on what basis many of the awards are made - in fact, they appear to be internally inconsistent. (Bailey).

Concern has been raised that there will be a lack of equity in the two types of VOL "judgements" - i.e. court awards vs C/B parameter values. Nevertheless, as noted, these two sets of values address different situations. There does not seem to be a good argument why the C/B technique should allow for the peculiarities of legal settlements.

"BEFORE" AND "AFTER" VALUES

Broome has raised the argument that the best estimate would be made after an accident when the individual(s) to die are known. And that that individual in these circumstances, could be judged to place an "infinite" value on his life. This argument would lead to a paralysis in decision-making as any course of action, including doing nothing, carries some risk of death. Moreover, effectively we are seeking the best estimate at a given point in time before the action is decided. This is what our estimates give. Nevertheless, the difference between the willingness of a population to accept a certain risk for a certain compensation, and the judged need to compensate the estate of the actual victim is of interest. This argument may very well be the basis for the large difference between the parameter estimates and the court awards.

CATASTROPIC SITUATIONS

C/B studies can apply to situations in which only a few lives are at risk or in which there is the risk of catastrophic loss of life. It has been speculated that the sudden and simulataneous loss of, say, 1,000 lives carries considerably more social loss than would be represented by (1,000) x (the VOL parameter value) (See, for example, Johri 1982). Recent work (Slovic, et al 1984), however, casts doubt on this and concludes that there is no good support for this view Schelling provides additional information to support this lack of evidence.

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Beyond any question of evidence, however, it will be clear that the concept of social cost is based on a different philosophy from that, for example, of the WTP. The WTP value, based on the individual's own perspective, presumably would not change if he were involved in a catastrophe. And it is far from clear that - aside from the sense of shack - a catastrophe actually carries disproportionate social cost from the deaths alone.

5. COST-EFFECTIVENESS APPROACH

As stated at the outset, this study has been concerned with the VOL parameter in C/B studies. It should be noted that in some cases it may very well be possible to use a cost-effectiveness (C/E) approach - i.e. the decision could be seen as choosing the course of action which yields the same output at the least cost. In this case the decision would yield the minimum cost of a life saved. The use of the C/E approach would avoid the controversy which may still be associated with the incorporation of the VOL component in a C/B study.

VIII. SUMMARY AND RECOMMENDATIONS

1. SUMMARY

There is a well-founded rationale for the use in C/B analyses of a parameter to represent the worth of reductions in the risk of death: this reduction is a reality in many cases, and often in itself is the source of costs. If the risk reduction factor is not explicitly represented, the result has been the implicit ascription to the parameter of a very wide range of values. (See Table I). As a positive rationale, the approach to the estimation of the VOL parameter which has evolved is well-based philosophically, in terms of economic theory, and is supported empirically by studies based on several perspectives.

Three approaches have been followed in the derivation of estimates of the parameter which represents the worth of the reduction of the risk of death - termed in earlier studies the "Value of Life" - a term which is still used, although generally now in the sense just described.

Of these three approaches - insurance; earnings-based; and, "Willingness to Pay" (WTP) -WTP has become dominant. Concerns about this approach in the view of this study (as discussed) are not well- founded.

The ideal approach would be to determine the WTP of the population actually concerned in a project. In application, this is extremely difficult, if not impractical. The VOL established by the study estimates provides a reasonable surrogate value for the general public. These WTP-based estimates are certainly not perfect or precise, and this is a major reason to test a project with a range of values.

The range of values from the various approaches, and studies within the approaches, are given in Table II.

The contrasts and inconsistencies between the various approaches are given in brief reference in Table II and discussed in the Approahces Section. They could be summarized as follows:

a) Insurance - Assumes life insurance level which a man should carry to fulfill his obligations equates to the VOL.

b) Earnings - Assumes that the VOL equates to the value of the individual to society, as found from the Present Value of future earnings.

c) WTP - Assumes that the fairest and most accurate estimate is provided by an individual for himself. Within the concept, three sources of estimates have been established:

   1) That represented by the wage premium obtained by risky occupations;

   2) That represented implicitly by people's choices in safety cost-benefit trade-offs;

   3). That represented by people's response to survey-type queries.

In the application of the WTP concept, the estimates applied should be derived from:

1) Similar risk levels, and for

2) Similar populations.

2. RECOMMENDATIONS

It is recommended that in C/B analyses:

- For the general population, when the risk to the individual is of the order of 10^{-4}, a WTP-based range of 0.3×10^6 to 1.5×10^6 ('85C$) be used for cases where conservative estimates are justified, and 0.5×10^6 to 0.8×10^6 otherwise.

- Projects be tested for acceptance at the low end of the range and for rejection at the high end;

- In the analyses, account be taken of economic benefits (e.g. low housing costs) already received by the population, as risk compensation;

- Where appropriate, the cost-effectiveness approach be used to avoid any controversy which might be associated with a VOL;

- Consideration be given to the study of the VOLs implicit in Canadian Government SAR operations;

- There is not a well-established argument for treating the VOLs lost in catastrophes differently from the VOLs of individuals.

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